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## (54) Inulin products with improved nutritional properties

(57) The invention relates to novel inulin products and compositions thereof, to their manufacture and to their use for modulating the bacterial flora and the fermentation pattern of inulin in the large intestine of humans and mammals, to their use for providing improved inulin-associated nutritional effects/benefits, and to their use for the manufacture of a pharmaceutical composition for providing said effects/benefits in humans and mammals.

The novel inulin products consist of a mixture of an easily fermentable inulin (EFI) component (preferably an oligofructose, an agave inulin, or a mixture thereof) and a hardly fermentable inulin (HFI) component (preferably a long-chain inulin with a  $\overline{DP} \geq 20$ , typically chic-

ory inulin with a  $\overline{DP} \geq 23$ ), in a weight ratio ranging from 10/90 to 70/30.

The nutritional effects include improved mineral absorption, particularly calcium and magnesium, bone mineral density increase, reduction of bone mineral density loss, improvement of bone structure, modulation of lipid metabolism, stimulation of the immune system, and anti-cancer effects. The novel inulin products are particularly suitable for the manufacture of a composition or a medicament for preventing, for postponing and for treating osteoporosis in humans, particularly postmenopausal women.

**Description****Field of the invention**

5 [0001] This invention relates to novel inulin products and compositions thereof, to their manufacture and to their use for modulating the bacterial flora composition and the fermentation pattern of inulin in the large intestine of humans and mammals, to their use for providing improved inulin-associated nutritional effects, and to their use for the manufacture of a pharmaceutical composition for providing said effects in humans and mammals.

**10 Prior art and technological background**

[0002] Inulin is a fructan-type carbohydrate, consisting mostly of fructose units, which occurs in many plants as a reserve carbohydrate. Inulin can be produced by certain bacteria and can also be enzymatically produced *in vitro* from sucrose. Inulin naturally occurs as a polydisperse mixture of molecules which are composed of fructosyl units forming linear chains in which the fructosyl units are linked to one another mainly by a  $\beta(2,1)$  bound. Said linear chains are possibly bearing one or more side chains essentially composed of fructosyl units, thus forming branched inulin molecules with a fructosyl-fructosyl linkage at the branching point, said linkage being commonly formed by a fructosyl-fructosyl  $\beta(2,6)$  bound. Inulin molecules from plant origin mostly contain one terminal glucosyl unit. Accordingly, inulin molecules can be represented by the formula  $GF_n$  or  $F_m$  wherein G represents a terminal glucosyl unit, F represents a fructosyl unit and n and m represent the number of fructosyl units linked to one another through a  $\beta(2,1)$  and/or a  $\beta(2,6)$  bound. The number  $n+1$ , respectively m, indicates the degree of polymerisation (DP) of the inulin molecule. Inulin is further characterised by its (number) average degree of polymerisation, represented by  $(\bar{DP})$ . This is the value which corresponds to the total number of saccharide units (G and F units) in a given inulin sample divided by the total number of inulin molecules in said sample, without taking into account the monosaccharides glucose (G) and fructose (F) and the disaccharide sucrose (GF) which are possibly present in the sample. The average degree of polymerisation  $(\bar{DP})$  is commonly determined by the method described by De Leenheer et al. (1).

[0003] Native inulin from plant sources (i.e. the inulin as present in the plant) appears as a polydisperse mixture of mostly linear polysaccharide chains with a (DP) ranging from 2 to about 100, whereas inulin molecules from bacterial origin usually have much higher (DP) values, even up to about 115.000. Plant inulin has a  $(\bar{DP})$  which largely depends on the plant source and on the harvest, storage and processing conditions. Natural (or standard grade) inulin indicates herein inulin which has been extracted from plant sources, purified and isolated, without applying a treatment for reducing or increasing its  $(\bar{DP})$  and usually has a  $(\bar{DP})$  which is about 1 unit lower than the  $(\bar{DP})$  of the corresponding native inulin.

[0004] Inulin molecules with a low degree of polymerisation, usually defined as a (DP) < 10, are named inulo-oligosaccharide(s), fructo-oligosaccharide(s) or oligofructose. These terms are commonly, and also herein, used interchangeably. Oligofructose is also termed herein short-chain inulin.

[0005] Inulin is commonly manufactured from plant sources, mainly from roots of Chicory (*Cichorium intybus*) but also from tubers of Jerusalem artichoke (*Helianthus tuberosus*) and from the piña (head) of the Blue agave plant, in which inulin can be present in concentrations up to about 20 wt% (hereinafter wt% means per cent (%)) by weight (wt) on fresh plant material. Inulin can be readily extracted from said plant parts and purified according to conventional techniques.

[0006] Natural inulin from chicory, respectively from J. artichoke, commonly appears as a polydisperse mixture of slightly branched chains (typically chains with less than 2 per cent, respectively less than 1 per cent, branching) with a (DP) ranging from 2 to about 70, respectively from 2 to about 40. Natural (standard grade) chicory inulin has a  $(\bar{DP})$  of about 10 and natural (standard grade) inulin from J. artichoke has a  $(\bar{DP})$  of about 6.

[0007] Natural inulin from agave appears as a polydisperse mixture of highly branched chains with a  $(\bar{DP})$  commonly ranging from about 14 to about 17.

[0008] At industrial scale, chicory inulin is conventionally obtained by extraction of shredded chicory roots with hot water yielding a crude inulin solution which is subsequently purified by depuration (treatment with lime followed by carbonatation and filtration) and by refining (involving treatment over ion-exchangers, treatment with active carbon and filtration). Standard grade inulin is then commonly obtained from the purified and refined solution by spray-drying. Optionally, monomeric and dimeric saccharides are removed from the purified and refined solution (e.g. by column chromatographic separation as described in EP 0670 850) to yield via spray-drying an inulin grade with a standard  $(\bar{DP})$  of about 10 which is about free of monomeric and dimeric saccharides. Optionally the purified and refined solution can be fractionated to remove monomeric and dimeric saccharides as well as oligofructose (e.g. by directed crystallisation as described in EP 0 769 026) and the fractionated inulin is then isolated in particulate form by spray-drying. Depending on the manufacturing process, chicory inulin with a  $(\bar{DP})$  ranging from about 10 (standard grade) to about 30, and even more, can be obtained.

[0009] Similarly, agave inulin can be obtained at industrial scale by squeezing, or extracting with water, shredded heads or pulp from Blue agave, followed by conventional purification, refining and isolation of the inulin e.g. via spray-drying.

[0010] Inulin with a  $(DP) \geq 20$  is termed herein long-chain inulin whereas inulin with a  $(DP)$  from 10 to  $< 20$  is termed herein medium-chain inulin.

[0011] Inulin from chicory is for example commercially available as RAFTILINE® from ORAFTI (Tienen, Belgium) in various grades. Typical RAFTILINE® grades are RAFTILINE® ST (with a  $(DP)$  of about 10 and containing in total about 8 % by weight glucose, fructose and sucrose) and RAFTILINE® HP (with a  $(DP)$  of at least 20, commonly with a  $(DP)$  of about 25, and virtually free of glucose, fructose and sucrose).

[0012] Agave inulin is commercially available, for example as GAVEDIET® PR with a  $(DP)$  of 14-16 and containing in total about 5 % by weight of glucose and fructose, from Industrias Colibri Azul S.A. de C.V., Mexico.

[0013] Oligofructose can be obtained according to techniques which are known in the art, including enzymatic in vitro synthesis from sucrose, as for example described in US 5,314,810, and partial hydrolysis of inulin, as for example described in EP 0 917 588.

[0014] Oligofructose prepared by enzymatic hydrolysis of chicory inulin is commercially available in various grades, for example as RAFTILOSE® from ORAFTI (Tienen, Belgium), e.g. RAFTILOSE® L95 (liquid form) or RAFTILOSE® P95 (powder form), both with a content of about 95 % oligofructose (% is wt% on total carbohydrates) with a  $(DP)$  from 2 to 9, typically with a  $(DP)$  mainly from 2 to 7, a  $(DP)$  of about 4.5, and containing about 5 % in total (% is wt% on total carbohydrates) of glucose, fructose and sucrose, and RAFTILOSE® L85, liquid form with a content of about 85 % oligofructose (% is wt% on total carbohydrates) with a  $(DP)$  from 2 to 9, typically a  $(DP)$  mainly from 2 to 7, a  $(DP)$  of about 3.5, and containing about 15 % in total (% is wt% on total carbohydrates) of glucose, fructose and sucrose.

[0015] Unless otherwise specified, the term inulin used herein refers to linear as well as branched inulin, and includes inulin molecules with a  $(DP) < 20$  as well as inulin molecules with a  $(DP) \geq 20$ .

[0016] In the food and feed industry, oligofructose is widely used as a low-calorie partial or complete replacement for sugar, providing sweetness, body and mouthfeel, whereas inulin of a  $(DP)$  of at least about 10 is utilised (i) as a partial or complete low-calorie replacement for sugar in combination or not with one or more high intensity sweeteners, providing body and mouthfeel, as described e.g. in patent application WO 93/02566, (ii) as a texture improver, e.g. as described in patent application WO 94/22327, and (iii) as a low-calorie replacement for fat. The use of inulin as fat replacer results from the fact that inulin can form with water a particle gel with a stable, homogeneous, creamy structure with excellent organoleptic properties as e.g. described in patent applications WO 93/06744 and WO 94/19973.

[0017] Inulin molecules with a  $(DP) > 10$  as well as oligofructose molecules with a  $(DP) < 10$ , are not hydrolysed by human digestive enzymes. Accordingly, these molecules pass the upper part of the digestive tract and the small intestine unaltered (Ellegård et al. (2)) and reach almost quantitatively the large intestine where they are fermented by specific intestinal bacteria (Roberfroid et al. (3)). As a result thereof, inulin and oligofructose present highly interesting nutritional properties.

[0018] Firstly, inulin and oligofructose are considered as dietary fibres. They reach the large intestine unaltered, thus providing carbon energy to the microflora in the large intestine. In this manner, inulin and oligofructose are stimulating the growth of gut bacteria in the large intestine which has a beneficial effect on the gut function, including a bulking effect (i.e. increase of the bacterial biomass) which in turn results in an increased stool weight, an increased stool frequency and a relief of constipation (Roberfroid (4)).

[0019] Furthermore, it has been found that inulin and oligofructose have a strong bifidogenic effect because inulin and oligofructose selectively stimulate the growth and metabolic activity of Bifidobacteria and Lactobacilli. Besides, while the counts of intestinal Bifidobacteria are significantly increased by the oral intake of inulin or oligofructose, a concomitant significant reduction of the counts of undesirable or pathogenic bacteria, such as e.g. Clostridia and Escherichia, in the large intestine has been observed (Gibson et al. (5) and Wang (6)). The intake of inulin and oligofructose thus largely modifies and modulates the gut flora by selectively increasing colonisation of the large intestine by beneficial bacterial species, typically Bifidobacteria, while suppressing the growth of undesirable bacterial species, which in turn results in favourable prophylactic and curative effects on intestinal disorders of the host.

[0020] *In vivo* experiments with healthy volunteers showed inulin (RAFTILINE® ST) and oligofructose (RAFTILOSE® P95) to be bifidogenic to the same extent (Gibson et al. (7)), while *in vitro* experiments revealed that inulin ( $(DP) \geq 10$ ) is fermented in the large intestine about twice as slowly as oligofructose ( $(DP) < 10$ ) (Roberfroid et al. (3)).

[0021] From these observations it follows that oligofructose is almost completely fermented in the proximal part of the large intestine, i.e. the ascendent part, whereas inulin is likely to reach to a more or lesser extent also more distal parts of the large intestine, i.e. the transversal and descendent parts, where it is fermented.

[0022] *In vitro* tests revealed that agave inulin is about as easily fermented as oligofructose. Accordingly, it is assumed that agave inulin is also almost completely fermented in the proximal part of the large intestine of humans and mammals.

[0023] Moreover, it has been disclosed that oligofructose and inulin have preventive and curative effects with respect to the genesis and growth of certain cancers such as colon cancer (WO 98/52578) and mammary cancer (EP 0 692 252).

[0024] The effects against mammary cancer seem to be related to an immunomodulating effect, particularly a stimulating effect on the immune system, of oligofructose, inulin and/or their fermentation products, mainly short chain fatty acids (SCFA) (Namioka et al. (8)).

[0025] With respect to colon cancer (usually resulting from pre-neoplastic lesion formation in the distal part of the colon), it has been reported that long-chain inulin, i.e. inulin with a ( $\overline{DP}$ )  $\geq 20$ , is more effective in preventing the genesis of colon cancer and in inhibiting the growth of colon cancer, than oligofructose (with a (DP)  $< 10$ ) and standard grade chicory inulin (with a ( $\overline{DP}$ ) of about 10) (WO 98/52578).

[0026] Furthermore, it has been found in studies with healthy human volunteers who were slightly hyperlipidemic, that the consumption of oligofructose or inulin has beneficial effects on lipid metabolism since the consumption resulted in reducing the level of serum triglycerides and cholesterol (mainly LDL cholesterol) compared to a control placebo treatment (Brighenti et al. (9) and Jackson et al. (10)). Moreover, it has been demonstrated in rat experiments that the addition of oligofructose or inulin to a fat-rich diet reduced serum cholesterol as well as serum triglycerides by more than 50 % compared to a control group (Kok et al. (11)).

[0027] Furthermore, positive effects of the consumption of oligofructose and inulin on the intestinal absorption of minerals, particularly calcium (Ca), magnesium (Mg) and iron (Fe), as well as on the bone mineral density (BMD), have been found in various studies.

Shimura et al. (12), Levrat et al. (13), Rémésy et al. (14), Tagushi et al. (15) and Scholz-Ahrens et al. (16) reported studies with rats in which an increased absorption of calcium, and in some cases other minerals including magnesium, was demonstrated as a result of oral consumption of inulin or oligofructose. Ohta et al. (17) and Baba et al. (18) formulated the hypothesis that the positive effects of non-digestible carbohydrates on Ca and Mg absorption occur at the level of the large intestine. Up to then, it was generally accepted that mineral absorption occurred mainly via the small intestine. Delzenne et al. (19) reported that a diet supplemented with 10 wt% of either inulin (RAFTILINE® ST) or oligofructose (RAFTILOSE® P95) resulted in a strong absorption increase for magnesium and calcium and a moderate absorption increase for iron in healthy rats, and noted almost the same effect for inulin (RAFTILINE® ST) compared to oligofructose (RAFTILOSE® P95). Brommage et al. (20) disclosed a similar increase in Ca absorption in healthy rats fed a diet supplemented with 5 wt% oligofructose (RAFTILOSE® P95). Taguchi et al. (15) reported that in ovariectomised rats oligofructose (2.5 wt% and 5 wt% in the diet) increased mineral uptake, particularly Ca and Mg absorption, and increased bone density thus preventing bone loss caused by oestrogen deficiency. Using the same model, Scholz-Ahrens et al. (16) observed a dose-dependent effect of oligofructose (RAFTILOSE® P95) (at 2.5; 5 and 10 wt% in the diet) on calcium absorption and on bone mineralisation. In that study, oligofructose also significantly reduced the osteoporotic loss of the bone trabecular structure caused by ovariectomy. Furthermore, an increased Ca absorption with a concurring increased BMD in rats fed a diet containing 5 wt%, respectively 10 wt%, inulin (RAFTILINE® HP) was reported by Lemort et al. (21).

[0028] The indications that inulin and oligofructose can positively influence the absorption of minerals from the diet and affect the uptake of minerals in the bone tissue, leading to increased BMD, are of high importance for human health. Indeed, calcium uptake in the body, bone mineral density increase, as well as the possibility to prevent, to slow down or to curb bone mineral density reduction, are very important for human populations with a typical Western-type lifestyle and food pattern, since in these populations there occurs with increasing age, particularly in post-menopausal women, a dysbalance between mineral uptake and mineral resorption and excretion. Said dysbalance results in a reduction of BMD and in bone fragilisation, which in a pronounced stage is known as osteoporosis. In an advanced stage, osteoporosis leads in turn to a high incidence of bone fractures. Accordingly, it is very important to ensure the building up during the growth phase of children and adolescents of skeletal elements with a high BMD. Such skeletal elements will indeed resist longer to demineralisation caused by any factor, and this may thus postpone or even avoid bone fracture due to advanced osteoporosis. In view of the above, it is also most important to be able to reduce possible losses of bone mineral content in adults in order to prevent or to maximally delay undesirable osteoporosis-related conditions, and in particular to slow down the post-menopausal demineralisation leading to osteoporosis and eventually to bone fracture. Furthermore, it is very important to be able to remedy conditions of osteoporosis, in particular in case of the occurrence of osteoporosis-related bone fractures. At last, it is highly desirable to be able to stimulate and increase mineral uptake and formation of bone structure in case of necessity, for example in case of accidental bone fractures in children, adults and elderly people.

[0029] In view thereof, the disclosures regarding the increased mineral absorption in rats have received much attention from the medical world and several studies have been made in order to examine Ca absorption from the diet and to increase Ca uptake in the bone tissue, in order to increase or improve BMD and bone structure in humans. Ellegård et al. (2) determined the mineral balance in ileostomy volunteers who were administered 15 g/day of either inulin (RAFTILINE® ST) or oligofructose (RAFTILOSE® P95). The intake of neither inulin nor oligofructose was found to alter the mineral excretion from the small intestine, thus confirming that the effect of inulin and oligofructose on mineral absorption does not occur in the small intestine but essentially takes place in the large intestine (also termed the colon). Studies by Coudray et al. (22) with healthy male adults (metabolic balance method) showed a significantly

- increased Ca absorption with a dietary intake of 40 g inulin per day. In studies (dual stable isotopes method) with healthy male adolescents, Van den Heuvel et al. (23) found a significant increase in Ca uptake upon consumption of 15 g/day oligofructose (RAFTILOSE® P95).

[0030] The beneficially nutritional effects resulting from the intake of oligofructose and inulin apparently are the result of their fermentation in the large intestine. However, as reported by Roberfroid et al. (3), the fermentation rate of inulin is much slower than the one of oligofructose.

[0031] Furthermore, *in vitro* experiments (unpublished results) with human faecal slurries even indicated to the inventors that when long-chain inulin (i.e. inulin with  $(DP) \geq 20$ ), was essentially free from oligofructose, i.e. inulin of  $(DP) < 10$ ), its fermentation hardly started.

[0032] The above observations, on the one hand the improved nutritional effects of inulin, particularly of long-chain inulin, and, on the other hand, the difficult and slow start of the fermentation and the resulting low fermentation rate of inulin, particularly long-chain inulin, in the large intestine, clearly lead to a technical problem which limits and even prevents the use of long-chain inulin to maximally generate nutritional benefits in humans and mammals.

[0033] Furthermore, in most of the nutritional studies disclosed so far, a daily consumption of relatively high amounts of oligofructose or inulin have been used, namely 15 g to 40 g/day in human studies and 2.5 wt% to 10wt% and even 20 wt% of the diet in rat studies. Extrapolated to humans, a rat diet containing 2.5 wt% to 10 wt% oligofructose or inulin would correspond to an amount oligofructose or inulin of about 15 g to 60 g/day. Such relatively high daily amounts also constitute a further technical problem for the use of inulin for nutritional purposes, particularly for generating improved beneficially nutritional effects in humans, because, as is known, such relatively high doses may cause intestinal side effects, such as too much flatulence, too much intestinal pressure, intestinal cramps and even diarrhoea.

### Object of the invention

[0034] It is an object of the present invention to provide a novel inulin product and compositions thereof presenting improved nutritional properties for humans and mammals compared to known inulin products, without imparting intestinal side effects.

[0035] It is another object of the present invention to provide a novel inulin product and compositions thereof which modulate the bacterial flora composition in the large intestine of humans and mammals and which modulate the fermentation pattern of inulin in humans and mammals.

[0036] It is a further object of the present invention to provide the use of said novel inulin product and compositions thereof for generating improved nutritional effects in humans and mammals, in particular increased mineral absorption.

## Description of the invention

35 [0037] In the search for improved inulin products, the inventors have surprisingly found a novel inulin product comprising a hardly fermentable inulin such as e.g. a long-chain inulin that, in spite of the above adverse indications for using such an inulin, nevertheless provides a solution to one or more of the mentioned and other problems.

40 [0038] According to one embodiment of the present invention, the inulin product of the invention consists of a mixture of an easily fermentable inulin component (hereinafter EFI) and a hardly fermentable inulin component (hereinafter HFI) in a specific weight ratio EFI/HFI ranging from 10/90 to 70/30.

45 [0039] In a preferred inulin product of the invention, said weight ratio of EFI/HFI is preferably ranging from 20/80 to 65/35, more preferably from 35/65 to 65/35, and even more preferably from 40/60 to 45/55, typically about 50/50.

50 [0040] By easily fermentable inulin (EFI) is meant herein linear as well as branched inulin-type products which are completely or almost completely fermented in the proximal part (the ascendent part) of the large intestine of humans and mammals. Typical EFI are short-chain inulin (i.e. inulin with a (DP) < 10) and agave inulin (i.e. a branched inulin).

55 [0041] By hardly fermentable inulin (HFI) is meant herein linear as well as branched inulin-type products of which the fermentation hardly starts in the proximal part of the large intestine and which are mainly fermented, though at a low rate, in the distal part (the transversal part and/or the descendent part) of the large intestine of humans and mammals. Typical HFT are long-chain inulin, i.e. linear as well as branched inulin with a  $(DP) \geq 20$ , and inulin in a particular crystallographic form or a particular physical appearance form which does not enable easy and significant fermentation in the proximal part of the large intestine of humans and mammals.

60 [0042] Short-chain inulin has preferably a (DP) ranging mainly from 2 to 7, with minor amounts, preferably less than 5 %, more preferably less than 3 % inulin of (DP) 8 to 9 (% is wt% on total inulin).

65 [0043] Long-chain inulin has preferably a  $(DP)$  of at least 23, more preferably of at least 25, even more preferably of at least 30.

70 [0044] In a preferred embodiment, the inulin product of the invention consists of a mixture of a EFI component consisting of a short-chain inulin, agave inulin, preferably agave inulin with a  $(DP) < 20$ , or any mixture thereof, and a HFI component which is a long-chain inulin. A preferred short-chain inulin is oligofructose. A preferred long-chain inulin is

chicory inulin and another preferred one is long-chain inulin from bacterial origin.

[0045] In a more preferred embodiment the inulin product of the invention consists of a short-chain inulin component and a long chain chicory inulin component in the above indicated EFI/HFI weight ratios. In a highly preferred embodiment of this inulin product, the EFI/HFI weight ratio ranges from 35/65 to 65/35, most preferably from 40/60 to 45/55, and in this inulin product the total content of inulin with (DP) = 9 and (DP) = 10, including molecules of formula GF<sub>n</sub> and F<sub>m</sub> as defined above, is preferably maximally 15 %, more preferably maximally 10 %, even more preferably maximally 5 %, most preferably maximally 2 % (% is wt% on total inulin, determined by gas liquid chromatography (GLC) analysis according to De Leenheer et al. (1)).

[0046] The inulin product of the invention surprisingly presents significantly improved nutritional properties and its oral or enteral intake provides one or more significantly improved nutritional effects/benefits for humans and mammals compared to known inulin products, being oligofructose, medium-chain inulin, as well as long-chain inulin. Furthermore, the oral or enteral intake of the inulin product of the invention provides said improved nutritional effects/benefits in humans and in mammals commonly at a lower daily dose than the daily dose which is needed of known inulin products to produce, if possible at all, such nutritional effects.

[0047] The inulin product of the invention has the potential to quickly and significantly modify and modulate the composition of the bacterial flora in the large intestine of healthy and diseased humans and mammals, in the proximal part as well as in the distal part of the large intestine.

[0048] Without being bound by the following hypothesis, the inventors assume that the improved nutritional benefits of the inulin product of the invention in humans and mammals result from the presence of an EFI component and a HFI component in the defined specific weight ratio, which is such that the specific amount of easily fermentable inulin in said inulin product selectively stimulates the growth and metabolic activity of Bifidobacteria and other beneficial bacteria in the proximal part of the large intestine, thus modulating the current bacterial flora into a flora composition much more consisting of beneficial bacteria and much less of undesirable bacteria than the current flora composition, and that these activated bacteria are dragged together with the specific amount of unaltered hardly fermentable inulin of the inulin product of the invention from said proximal part into the distal part of the large intestine. On arrival in the distal part, the activated bacteria, under pressure of the depletion of EFI (being consumed by the bacteria in the proximal part of the large intestine), trigger the fermentation of the HFI which, accordingly, will be quickly and completely fermented in the distal part (the transversal as well as the descendent part) of the large intestine. The inulin product of the invention thus provides on the one hand a HFI component which will reach almost unaltered the distal part of the large intestine where its fermentation is most beneficial, whereas on the other hand, through its EFI component, the inulin product of the invention ensures that the fermentation of said HFI in the distal part of the large intestine is readily started by activated bacteria and is proceeding well to complete fermentation, which in turn results in providing one or more improved inulin-associated nutritional effects/benefits.

[0049] According to another, highly preferred embodiment of the invention, the inulin product according to the invention is an industrial grade inulin product, which means an inulin product composed of a mixture of industrial grade short-chain inulin or agave inulin or a mixture thereof as EFI component and industrial grade long-chain inulin as HFI component in an above indicated specific weight ratio, preferably a weight ratio EFI/HFI ranging from 35/65 to 65/35.

[0050] Preferably, in said industrial grade inulin product, the total content of inulin with (DP) = 9 and (DP) = 10 is maximally 15 %, more preferably maximally 10 %, even more preferably maximally 5 % and most preferably maximally 2 % (% is wt% on total inulin).

[0051] Accordingly, industrial grades of oligofructose can be used as EFI component in the industrial grade inulin product according to the invention, which may contain in total up to about 15 %, preferably maximally about 10 %, more preferably maximally about 5 % glucose, fructose and sucrose (% = wt% on total carbohydrates in the oligofructose product).

[0052] In still a further preferred industrial grade inulin product according to the invention, the oligofructose component consists of more than 43 wt% of inulin-type molecules of formula F<sub>m</sub> wherein F indicates a fructosyl unit and m is the degree of polymerisation, ranging from 2 to 9, preferably mainly from 2 to 7.

[0053] Typically industrial grades of oligofructose which are suitable as EFI component of the industrial grade inulin product according to the invention are RAFTILOSE® L85, RAFTILOSE® L95 and RAFTILOSE® P95, which are all oligofructose grades obtained by enzymatic hydrolysis of chicory inulin. Suitable industrial grades of oligofructose can also be obtained by enzymatic *in vitro* synthesis from sucrose by known methods, for example according to patent US 5,314,810. A suitable industrial grade of agave inulin is GAVEDIET®PR.

[0054] Industrial grade long-chain inulin with a  $(DP) \geq 20$  which is suitable as HFI component for the industrial grade inulin product of the invention may contain inulin molecules with a (DP) from 10 to 20 up to about 45 % (% is wt% on total carbohydrates). Possibly present inulin molecules with a (DP) < 10 are calculated as part of the EFI component. In said industrial grade long-chain inulin, the content of glucose, fructose and sucrose is usually very low, typically less than about 2 % (% is wt% on total carbohydrates).

[0055] A typically industrial grade inulin which is suitable as HFI component of the industrial grade inulin product

according to the invention is chicory inulin RAFTILINE®HP.

[0056] In the industrial grade inulin product according to the invention, the weight ratio EFI (short-chain inulin) component / HFI (long-chain inulin) component is defined on the basis of the real short-chain inulin and real long-chain inulin present in the respective components, without taking into account the amounts of glucose, fructose and sucrose which are possibly present, and that the true amount of inulin product of the invention in said industrial grade inulin product corresponds to the sum of the amounts of real short-chain inulin and real long-chain inulin which are present in the industrial grade product.

[0057] In a further embodiment, the present invention relates to a method for preparing an inulin product and an industrial grade inulin product according to the invention, consisting in mixing the EFI component and the HFI component in the said specific weight ratio. The mixing can be carried out by conventional techniques, such as for example by dry mixing of the components or by wet mixing of the components, optionally followed by isolation of the formed inulin product in dry form via conventional techniques, e.g. via spray-drying. Wet mixing techniques include *inter alia* (a) mixing of the components dissolved, dispersed or suspended in a liquid, optionally followed by isolation of the formed inulin product via known techniques such as e.g. spray-drying, (b) mixing one of the components in dry form (preferably in powder form), in neat form or in solution, dispersion or suspension in a liquid, into the other component in neat form, in solution, dispersion or suspension in a liquid, the liquids being preferably the same, optionally followed by isolation of the formed inulin product by known techniques, typically by spray-drying, (c) preparing separately a solution, dispersion or suspension of each of the components in a liquid, followed by mixing them and isolation of the formed inulin product of the invention through co-drying techniques, especially co-spray-drying, and (d) agglomerating a dry mixture of said components in powder form by moistening with water in the liquid or vapour phase, followed by drying of the moist mixture in the presence of hot air, typically in an agglomerating chamber, followed by cooling and isolation of the formed particles. The particles can then be sieved to isolate an inulin product of the invention with a desired particle size while the particles outside said desired size can be recycled. The inulin product and commercial grade inulin product of the invention are preferably made by co-drying, preferably co-spray-drying, of both components in the specific weight ratio or by spray-drying one component while bringing the pulverised jet of said component during the spray-drying step into contact with the second component in particle form, in the desired specific weight ratio, in the presence of hot air in a drying chamber, thus forming co-dried particles or agglomerates. Isolation of the formed particles or agglomerates can be made conventionally.

[0058] Optionally, the mixing process, typically the mixing process which involves a spray-drying step, can include a conventional UHT (ultra-high-temperature) treatment step in order to produce an inulin product or industrial grade inulin product of acceptable microbiological quality.

[0059] The liquids used in the preparation of the inulin product or industrial grade inulin product of the invention should preferably not provoke hydrolysis of the components to a significant extent since otherwise the required specific weight ratio of the components might not be fulfilled any longer. The most suitable liquid is water which is a good solvent for short-chain inulin and agave inulin, as well as for long-chain inulin (at least at a temperature above about 80°C).

[0060] The process conditions of the wet mixing process should be appropriate which means that the combination of the process parameters, including kind of liquid, pH of the solution, dispersion or suspension, temperature, and retention time (*i.e.* the time the components and/or the formed inulin product remain in said conditions), are selected in such a manner that no, or at least no significant, hydrolysis or degradation of the components or of the formed inulin product or industrial grade inulin product occurs.

[0061] In a further embodiment the present invention relates to compositions containing an effective amount of the inulin product or of the industrial grade inulin product of the invention, and one or more other, edible or pharmaceutically acceptable components. Typical compositions include foods, drinks and feed compositions, pharmaceutical compositions (*i.e.* prophylactic compositions and therapeutic compositions), and intermediates thereof.

[0062] Said other, edible or pharmaceutically acceptable components are preferably selected from the group consisting of sugars (such as for example, glucose, fructose, sucrose, lactose, galactose, maltose, isomaltulose), polyols (such as for example sorbitol, lactitol, maltitol, isomalt, mannitol, xylitol), maltodextrins, hydrogenated glucose syrups, food or feed additives, food or feed ingredients, food or feed intermediates, food or feed products, liquids, drinks, sources of minerals, particularly sources of calcium, of magnesium and of iron, pharmaceutically acceptable excipients, therapeutically active ingredients or pharmaceutical compositions containing one or more active ingredients. By effective amount is meant herein an amount which provides said improved nutritional effects/benefits in humans and mammals when the composition is orally or enterally taken regularly, preferably at a daily dose.

[0063] A particularly advantageous and preferred composition according to the present invention comprises the inulin product or industrial grade inulin product of the invention in the presence of an edible or pharmaceutically acceptable, bio-available source of one or more minerals, particularly of calcium and/or magnesium and/or iron, such as for example dairy products and salts and complexes of calcium, magnesium and iron.

[0064] Typically the bio-available amount of a mineral in said source of minerals which is present in a daily dose of the composition of the invention equals an amount which corresponds to the recommended daily dose (RDI value) for

said mineral. However, said composition may also contain less or more of said bio-available mineral than the recommended daily dose.

[0065] The compositions according to the invention can be prepared by conventional techniques, including, for example, mixing an inulin product or industrial grade inulin product of the invention with at least one other, edible or pharmaceutically acceptable component, or, alternatively, by mixing the EFI component and the HFI component in the specified weight ratio together with one or more of said other, edible or pharmaceutically acceptable components, optionally followed by bringing the obtained composition in a desired form by conventional techniques. The composition of the invention may appear as a solid, a semi-solid such as a cream or paste, a gel, a liquid, a dispersion, a suspension or an emulsion, in any desired form. The composition may appear, for example, in the form of all kinds of food and feed products, e.g. as bread, cookies and biscuits, cheese and other dairy products, chocolate, jam, pudding and other dairy desserts, spreadable products, frozen desserts and ice-cream, in the form of a powder, an aggregate, a granulate, a tablet, a lozenge, a drink, a syrup, as a pharmaceutical composition such as e.g. a powder, an aggregate, a granulate, a tablet, a coated tablet, a capsule, a drink, a syrup, a composition for tube feeding or for enteral administration.

[0066] In a further aspect, the present invention relates to the use of an inulin product, an industrial grade inulin product or a composition according to the present invention, preferably via the intake of a daily dose, for modifying and modulating the bacterial flora composition in the large intestine, particularly in the distal part of the large intestine, of healthy and diseased humans and mammals, for modulating the fermentation pattern of inulin in healthy and diseased humans and mammals, as well as for providing one or more improved inulin-associated nutritional effects/benefits in healthy and diseased humans and mammals. The mammals are particularly dogs, horses, cats and rabbits.

[0067] In a further embodiment, the present invention relates to the inulin product and an industrial grade inulin product of the invention or a composition according to the invention, for use as a medicament, including a prophylactic and a curative medicament, in particular a medicament for modulating the bacterial flora composition in the large intestine, particularly in the distal part of the large intestine, of humans and mammals, for modulating the fermentation pattern of inulin in humans and mammals, as well as for providing one or more improved inulin-associated nutritional effects/benefits in healthy as well as in diseased humans and mammals.

[0068] In still a further embodiment, the present invention relates to the use of an inulin product or an industrial grade inulin of the invention for the manufacture of a medicament, particularly a medicament for modulating the bacterial flora composition in the large intestine, particularly in the distal part of the large intestine, of humans and mammals, for modulating the fermentation pattern of inulin in humans and mammals, as well as for providing one or more improved inulin-associated nutritional effects / benefits in healthy as well as in diseased humans and mammals.

[0069] Said improved inulin-associated nutritional effects/benefits include dietary fibre effects in the colon, particularly in the distal part of the colon, including the generation of beneficial metabolites such as SCFA's and the generation of bacterial biomass, the reduction of the colonic pH, a bifidogenic effect, particularly in the distal part of the large intestine, including an increase of the counts of Bifidobacteria with a concurrent reduction of the counts of non-desirable and/or pathogenic bacteria, which in turn will benefit the prevention and treatment of intestinal disorders and diseases.

[0070] Furthermore, said improved nutritional effects/benefits also include a modulation of the lipid metabolism, a stimulation of the immune system, the reduction of the risk of cancer, and preventive and curative effects against cancer, particularly against mammary cancer and colon cancer.

[0071] Further effects/benefits include improved absorption of minerals in the body, particularly of calcium and magnesium, improvement of the bone mineral density and of the bone structure in healthy as well as in diseased humans and mammals, and the possibility to curb or significantly reduce the bone demineralisation process in humans, particularly in post-menopausal women and in gastrectomised humans, in elderly and in diseased humans and mammals, particularly in humans suffering from osteoporosis.

[0072] Moreover, said effects/benefits also enable the building up of a strong skeleton in growing children, growing adolescents and in growing mammals, and to increase in said humans and mammals the peak bone mass, which in turn enables to prevent or postpone osteoporosis later in life, particularly in post-menopausal women.

[0073] Furthermore, the inventors surprisingly found that the amount of EFI present in the inulin products of the invention exerts such a pronounced activating effect on the intestinal flora that the amount of HFI present in said products is readily and completely fermented in the distal part of the large intestine. This property of said inulin products of the invention results in the fact that the improved nutritional effects/benefits can be obtained by a lower daily dose of said inulin products compared to the daily dose of known inulin products which is required to obtain a similar effect, if possible at all. The said improved nutritional effects/benefits in humans, e.g. improved mineral absorption, are indeed already obtained with a daily dose in adults of as little as about 4 g inulin product of the invention, either the inulin product per se, or included in the industrial grade inulin product or in a composition (g is gram of the true inulin product according to the invention).

[0074] The daily dose of true inulin product of the invention suitable for adults preferably ranges from about 4 g to about 12 g, corresponding to about 50 mg to about 150 mg/day/kg body weight, more preferably from about 6 g to about 10 g, and is typically about 8 g, and for babies and children the daily dose preferably ranges from about 40 mg

to about 400 mg/day/kg body weight. Said small daily dose of inulin product of the invention results in considerable additional benefits for humans since it increases the comfort of the inulin intake compared to the rather large corresponding quantities of known inulin products (ranging from about 15 g to about 40 g per day). Besides, as a result of said small daily taken quantity of inulin, the humans will not encounter the intestinal side effects which are often associated with the intake of rather large quantities of inulin, such as flatulence, intestinal pressure, bloating, intestinal spasms and/or diarrhoea.

5 [0075] The invention is further illustrated by the examples below.

10 Fig 1: represents a dionex chromatogram of an inulin product according to the invention consisting of a mixture of EFI (oligofructose with a (DP) mainly from 2 to 7) and HFI (chicory inulin with a ( $\overline{DP}$ ) of about 25) in a weight ratio 45/55.

15 Example 1: Rat study to evaluate the effect of the intake of an inulin product according to the invention compared to oligofructose and long-chain inulin on the absorption of calcium.

15 [0076] Calcium absorption was measured in four groups of Wistar male rats (groups of 9 or 10 rats; age of 6 weeks; weight of 160-180 g):

20 - group 1: control group, receiving a diet of standard semi-synthetic food corresponding to the recommendations of the American Institute of Nutrition with mineral content according to AIN 1976;

- group 2: group receiving said standard semi-synthetic food containing industrial grade oligofructose of (DP) mainly from 2 to 7;

- group 3: group receiving said standard semi-synthetic food containing industrial grade long-chain chicory inulin with a ( $\overline{DP}$ ) of about 25;

25 - group 4: group receiving said standard semi-synthetic food containing an inulin product according to the invention consisting of industrial grade oligofructose of (DP) mainly from 2 to 7 and industrial grade long-chain chicory inulin with a ( $\overline{DP}$ ) of about 25, in a weight ratio real EFI / real HFI of 45 / 55, prepared by co-spray-drying, corresponding to the product of Fig 1.

30 [0077] After gradual adaptation of the rats to the diet during three weeks, the rats were kept for a fourth week in metabolic cages and received the respective diet containing 10 wt% of the tested oligofructose or inulin product (100 g food + 100 g water per day). Food intake was monitored and the last four days of the fourth week the faeces and urine were collected to determine the digestive absorption of calcium. Calcium in urine samples was determined by atomic absorption spectrometry. Samples of the diet and of the lyophilised and grounded faeces were calcinated at 35 500°C, and the ashes were taken up in nitric acid/hydrogen peroxide, and after dilution with milli-Q water, calcium was determined by atomic absorption spectrometry.

The digestive absorption was calculated by the following formula:

40 - daily digestive absorption =

$$\text{quantity orally taken} - \text{quantity excreted via the faeces};$$

45 - % digestive absorption =

$$100 \times \{(\text{quantity orally taken} - \text{quantity excreted via the faeces})/\text{quantity orally taken}\}$$

50 The results are presented in Table 1 below.

The data of Table 1 show that compared to the control group, and taking into account that the urinary excretion of calcium did not differ amongst all 4 groups, calcium absorption was increased in all test groups, but only the increase of calcium absorption in group 4 (by about 20 %) was found to be statistically significant versus the control group.

Table 1:

Effect of oral intake of oligofructose or inulin on the intestinal absorption of calcium in the rat.				
5 Digestive calcium absorption (%)				
	Group 1** (control)	Group 2** (oligofructose)	Group 3 ** (long-chain inulin)	Group 4 (inulin product of invention)
M ± SD*	47.9±5.5	52.7±6.0	54.1±5.6	58.1±7.4
10 min-max	39.1-55.9	44.0-63.1	45.0-61.3	50.1-61.2

\* Mean value ± standard deviation;

\*\*: comparative

Example 2: Human study to evaluate the effect of the intake of an inulin product according to the invention compared to oligofructose on the calcium absorption in young adolescent girls.

**[0078]** Calcium absorption was measured in adolescent, healthy girls (11 to 14 years old; of 44 kg mean body weight). Ethical approval and informed consent were obtained in all cases. Only subjects were elected for the study with habitual calcium intakes between 500 mg and 1400 mg/day. Subjects were excluded from the study if they had a chronic gastrointestinal disease, renal failure, or disorders of calcium homeostasis, if they were taking prescription medication, smoking, were on a contraceptive pill or had a weight greater than the 90<sup>th</sup> percentile for age. The subjects were studied using a randomised, double-blind, cross-over design. The subjects were randomised in two separate groups to receive two packets of 4 g servings of oligofructose or inulin product according to the invention daily for 3 weeks and two packets of 4 g servings of placebo daily for 3 weeks. The studies were separated by a 2-week wash-over period. The subjects received oligofructose or inulin product of the invention and placebo in a random order, and the investigators were blinded to the treatment assignment.

**[0079]** Two identical protocols were carried out simultaneously. In Protocol I (n=30) the test product was industrial grade oligofructose with (DP) mainly from 2 to 7. In Protocol II (n=29) the test product was an inulin product according to the invention, composed of a mixture of industrial grade oligofructose with (DP) mainly from 2 to 7 and industrial grade long-chain chicory inulin with a (DP) of about 25, in a weight ratio of 45/55 (weight ratio on total real short-chain inulin and real long-chain inulin content), prepared by co-spray-drying, corresponding to the product of Fig 1. In both protocols the placebo was packed and presented in an identical manner to the oligofructose/inulin. At the end of each 3-week adaptation period (to 8 g/day), calcium absorption was measured using a previously validated dual tracer stable isotopes technique. Furthermore, a baseline urine sample was collected from the subjects. The subjects consumed a low-calcium breakfast and a glass of calcium fortified orange juice to which was added one 4 g packet of oligofructose, inulin product or placebo, and 10 mcg of <sup>46</sup>calcium. Immediately after breakfast 1.5 mg of <sup>42</sup>calcium was infused intravenously over 2 to 3 minutes. The mid-day meal contained approximately 400 mg calcium either as calcium fortified orange juice, milk or yoghurt. The evening meal contained another serving of calcium fortified orange juice, 10 mcg of <sup>46</sup>calcium and another 4 g packet of oligofructose, inulin product or placebo. The subjects consumed daily approximately 1300 mg calcium during the 8 week-study. A 48 hour urine collection was started immediately after isotope administration. Calcium absorption was measured by the ratio of the cumulative fractional excretion of the oral and intravenous isotopes in the 48 hour urine collection. Samples were purified using an oxalate precipitation method and isotope ratios were measured by thermal ionization magnetic sector mass spectrometry.

**[0080]** Compliance was assessed by a count of opened and unopened packets and any packet not accounted for was assumed to be unopened. The compliance for oligofructose and for the inulin product of the invention was very good as is shown by the data presented in Table 2 below.

Table 2:

Compliance		
compliance	oligofructose **	inulin product of invention
Mean ± SD*	95 % ± 7	94 % ± 12

\* Mean value ± standard deviation;

\*\*: comparative

**[0081]** The results of the calcium measurements are given in Table 3 below.

Table 3:

Calcium absorption in healthy adolescent girls			
Protocol carbohydrate	Calcium absorption % (as Mean $\pm$ SD)	p - value versus placebo (sucrose)	
<b>Protocol I</b>			
sucrose**	30.9 $\pm$ 10.0		
oligofructose**	31.8 $\pm$ 9.3		0.75
<b>Protocol II</b>			
sucrose**	32.3 $\pm$ 9.8		
inulin product of the invention	38.2 $\pm$ 9.8		0.007

\* Mean value  $\pm$  standard deviation;

\*\*: comparative

The results in Table 3 indicate that there was no significant difference ( $p = 0.89$ ) in calcium absorption between Protocol I and Protocol II with sucrose (placebo), and also that oligofructose did not significantly alter calcium absorption. With the inulin product according to the invention, however, a significant increase in calcium absorption was obtained versus the placebo and also vis à vis oligofructose, i.e. from 31.8 % to 38.2 %, which corresponds to a relative increase of calcium absorption of 20 %.

[0082] Moreover, the study of the urinary calcium excretion showed that, as seen from the data presented in Table 4 below, there were no significant differences in urinary calcium excretion between any of the study groups.

[0083] From the above experiment it can be concluded that, at the currently recommended intake of calcium (about 1300 mg/day for adolescent girls), the intake of an amount as little as 8 g/day inulin product according to the invention significantly increased the calcium absorption, without a compensatory increase in urinary calcium excretion, whereas the intake of 8 g/day oligofructose by the same population under the same experimental conditions did not significantly increase calcium absorption.

Table 4:

Urinary calcium excretion in healthy adolescent girls			
Protocol carbohydrate	Urinary calcium excretion mg/day (M $\pm$ SD) *	p - value versus placebo (sucrose)	
<b>Protocol I</b>			
sucrose**	71 $\pm$ 48		
oligofructose**	79 $\pm$ 50		0.75
<b>Protocol II</b>			
sucrose**	65 $\pm$ 54		
inulin product of the invention	71 $\pm$ 50		0.57

\* Mean value  $\pm$  standard deviation;

\*\*: comparative

Example 3: Rat study evaluating the effect of the intake of an inulin product of the invention compared to oligofructose on the absorption of magnesium

[0084] Magnesium absorption was measured in Wistar male rats (groups of 9 or 10 rats; age of 6 weeks; weight of 160-180 g) with:

- group 1 : control group, receiving a diet of standard semi-synthetic food corresponding to the recommendations of the American Institute of Nutrition with mineral content according to AIN 1976;
- group 2: group receiving said standard semi-synthetic food containing industrial grade oligofructose of (DP) mainly from 2 to 7;
- group 3: group receiving said standard semi-synthetic food containing an inulin product according to the invention consisting of industrial grade oligofructose of (DP) mainly from 2 to 7 and industrial grade long-chain chicory inulin

with a ( $\overline{DP}$ ) of about 25, in a weight ratio real short-chain inulin/real long-chain inulin of 45/55, prepared by co-spray-drying, corresponding to the product of Fig 1.

5 After three weeks of gradual adaptation to the diet, the rats were kept for a fourth week in metabolic cages and received their respective diet which contained 10 wt% of the tested oligofructose or inulin product (100 g food + 100 g water per day). Food intake was monitored and the last four days of the fourth week the faeces and urine were collected to determine the digestive absorption of magnesium. Magnesium was determined in the samples of urine, faeces and feed, by atomic absorption spectrometry and the digestive magnesium absorption was calculated as indicated in Example 1.

10 The results are shown below in Table 5.

Table 5:

Effect of oral intake of oligofructose or inulin product on the intestinal absorption of magnesium in the rat.			
Digestive magnesium absorption (%)			
	Group 1 ** (control)	Group 2 ** (oligofructose)	Group 3 (inulin product of invention)
Mean $\pm$ SD*	48.8 $\pm$ 5.3	71.3 $\pm$ 4.5	76.7 $\pm$ 6.7
min-max	39.3-57.0	65.0-78.6	67.6-90.4

20 \* Mean value  $\pm$  standard deviation;

\*\*: comparative

25 The data of Table 5 show that, compared to the control group, magnesium absorption was statistically significantly increased in groups 2 and 3, in particular in group 3 with a relative increase of magnesium absorption of about 57 %, and that the increase in magnesium absorption was more pronounced with the inulin product of the invention than with oligofructose.

30 Example 4: Evaluation of the effect of the intake of an inulin product of the invention compared to oligofructose and long-chain inulin on lipid metabolism in the rat.

35 [0085] The effect of oligofructose and inulin products on lipid metabolism was measured in Zucker male rats. Zucker rats have a mutation of the leptine receptor which makes that these rats rapidly develop fat tissue instead of lean meat tissue and present as further characteristics hypertriglyceridemia, insulin resistance and hepatic steatose.

The following groups of rats (groups of 7 rats; age of 5 weeks) were involved in the study:

40 35 - group 1 : control group, receiving a diet of standard feed;  
 - group 2 : group receiving a diet of said standard feed containing oligofructose of ( $DP$ ) mainly from 2 to 7;  
 - group 3: group receiving a diet of said standard feed containing long-chain chicory inulin with a ( $\overline{DP}$ ) of about 25;  
 - group 4: group receiving a diet of said standard feed containing an inulin product according to the invention consisting of oligofructose of ( $DP$ ) mainly from 2 to 7 and long-chain chicory inulin with a ( $\overline{DP}$ ) of about 25, in a weight ratio real short-chain inulin/real long-chain inulin of 45 / 55.

45 [0086] After one week of adaptation to the diet (control diet or diet containing respectively 5 wt% of oligofructose, long-chain inulin or inulin product according to the invention), the rats received the study diet containing 10 wt% of the respective tested product for 6 weeks and were then sacrificed. Then, according to standard techniques, the parameters fat tissue weight, liver weight, concentration of liver triglycerides and activity of the enzyme fatty acid synthase in the liver were determined.

The results are presented in Table 6 below.

Table 6:

Effect of oligofructose or inulin products on biometric and biochemical parameters in Zucker rats				
Group	Fat tissue weight (g)*	Liver weight (g) *	Liver triglycerides (mg/g liver) *	Activity of liver fatty acid synthase (FAS) (mU/mg protein) *
1 (control)**	5.94±0.23	18.32±0.40	452.44±72.05	32.31±1.88
2 (oligofructose)**	5.70±0.23	17.28±0.67	414.97±50.12	22.4±2.6
3 (long-chain inulin)**	6.06±0.28	18.17±1.32	500.66±62.68	25.3±2.6
4 (inulin product of invention)	4.99±0.19	14.83±0.60	286.64±47.73	13.7±0.52

\* Mean value ± standard deviation;

\*\*: comparative

From the data of Table 6 it clearly follows that the inulin product according to the invention has the most pronounced effect on lipid metabolism compared to oligofructose and long-chain inulin.

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## Claims

1. Inulin product consisting of a mixture of an easily fermentable inulin (EFI) component and a hardly fermentable inulin (HFI) component in a weight ratio EFI/HFI ranging from 10/90 to 70/30.

2. Inulin product according to claim 1 wherein the weight ratio of the EFI/HFI components ranges from 35/65 to 65/35.
3. Inulin product according to any one of claims 1 or 2 wherein the EFI component consists of a linear and/or a branched inulin-type product selected from the group consisting of short-chain inulin with a  $(DP) < 10$ , agave inulin, and any mixture thereof.
4. Inulin product according to any one of claims 1 to 3 wherein the HFI component consists of long-chain inulin with a  $(DP) \geq 20$ .
5. Inulin product according to claim 1 or claim 2 wherein the EFI component is oligofructose and the HFI component is long-chain chicory inulin with a  $(DP) \geq 23$ .
10. Inulin product according to claim 5 which is an industrial grade inulin product consisting of a mixture of industrial grade oligofructose containing maximally 15% in total of glucose, fructose and sucrose (% is wt % on total carbohydrates) as EFI component, and industrial grade long-chain chicory inulin with a  $(DP) \geq 23$  as HFI component, in a weight ratio real short-chain inulin / real long-chain inulin respectively contained in said industrial grade components which corresponds to the weight ratio defined in claim 1 or claim 2.
15. Inulin product according to claim 6 wherein the industrial grade oligofructose contains maximally 5 % in total of glucose, fructose and sucrose, (said % being wt% (per cent by weight) on total carbohydrates), the industrial grade chicory inulin has a  $(DP)$  of at least 23, and in which the total content of inulin with a  $(DP) = 9$  and a  $(DP) = 10$  is maximally 15 % (% is wt% on total inulin).
20. Method for preparing an inulin product as defined in any one of claims 1 to 7 consisting in dry mixing of the EFI component and the HFI component in the specified weight ratio or consisting in wet mixing of the EFI component and the HFI component in the specified weight ratio, followed by the isolation of the obtained inulin product, and said wet mixing or said isolation step is optionally including a spray-drying step.
25. Composition containing an inulin product as defined in any one of claims 1 to 7, and one or more other edible or pharmaceutically acceptable components.
30. Composition according to claim 9 wherein the one or more other edible or pharmaceutically acceptable components are selected from the group consisting of a sugar, a polyol, a hydrogenated glucose syrup, a maltodextrin, a food ingredient, a feed ingredient, a food additive, a feed additive, a food intermediate, a feed intermediate, a food product, a feed product, an edible liquid, a drink, an edible source of minerals, a pharmaceutically acceptable excipient, a therapeutically active ingredient and a pharmaceutical composition containing one or more active ingredients.
35. Composition according to claim 10 wherein the edible source of minerals contains a source of calcium, and/or a source of magnesium, and/or a source of iron.
40. Method for preparing a composition as defined in any one of claims 9 to 11 comprising mixing an inulin product as defined in any one of claims 1 to 7, or mixing the EFI component and the HFI component as defined in any one of claims 1 to 7, in the weight ratio defined in claim 1 or claim 2, with at least one other component as defined in any one of claims 10 to 11, optionally followed by bringing the composition in the desired form.
45. Use of an inulin product according to any one of claims 1 to 7 or of a composition according to any one of claims 9 to 11 for modulating the bacterial flora composition in the large intestine or in the distal part of the large intestine of humans and mammals.
50. Use of an inulin product according to any one of claims 1 to 7 or of a composition according to any one of claims 9 to 11 for modulating the fermentation pattern of inulin in the large intestine or in the distal part of the large intestine of humans and mammals.
55. Use of an inulin product according to any one of claims 1 to 7 or of a composition according to any one of claims 9 to 11 for providing one or more improved inulin-associated nutritional effects/benefits in humans and mammals compared to the effects provided by known inulin products or compositions thereof.

16. Use according to claim 15 wherein said improved nutritional effects/benefits are selected from the group consisting of dietary fibre effects, modulation of gut function, bifidogenicity, increased mineral absorption, increased absorption of calcium and/or of magnesium and/or of iron, bone mineral density increase, bone mineral content increase, peak bone mass increase, improvement of the bone structure, reduction of bone mineral density loss, reduction of loss of bone structure, modulation of lipid metabolism, stimulation of the immune system, prevention or reduction of the risk of cancer, prevention or reduction of the risk of colon cancer and prevention or reduction of the risk of breast cancer.

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17. Inulin product as defined in any one of claims 1 to 7 or composition as defined in any one of claims 9 to 11 for use as a pharmaceutical composition, being a medicament or a prophylactic composition.

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18. Use of an inulin product as defined in any one of claims 1 to 7 or of a composition as defined in any one of claims 9 to 11 for the manufacture of a pharmaceutical composition, being a medicament or a prophylactic composition.

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19. Use according to claim 18 of an inulin product as defined in any one of claims 1 to 7 or of a composition as defined in any one of claims 9 to 11 for the manufacture of a pharmaceutical composition for modulating the bacterial flora composition in the large intestine or in the distal part of the large intestine of humans and mammals.

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20. Use according to claim 18 of an inulin product as defined in any one of claims 1 to 7 or of a composition as defined in any one of claims 9 to 11 for the manufacture of a pharmaceutical composition for modulating the fermentation pattern of inulin in the large intestine or in the distal part of the large intestine of humans and mammals.

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21. Use according to claim 18 of a product as defined in any one of claims 1 to 7 or of a composition as defined in any one of claims 9 to 11 for the manufacture of a pharmaceutical composition for providing one or more improved inulin-associated nutritional effects/benefits in humans and in mammals compared to the effects provided by known inulin products or compositions thereof.

22. Use according to claim 21 wherein said improved inulin-associated nutritional effects/benefits are as defined in claim 16.

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23. Use according to claim 18 for the manufacture of a pharmaceutical composition for preventing or reducing the risk of osteoporosis or for treating osteoporosis in humans.

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24. Use according to claim 23 wherein the human is a post-menopausal woman.

25. Use according to claim 18 of a product as defined in any one of claims 1 to 7 or of a composition as defined in any one of claims 9 to 11 for the manufacture of a pharmaceutical composition for preventing or reducing the risk of cancer, of colon cancer or of breast cancer, or for the treatment of cancer, of colon cancer or of breast cancer.

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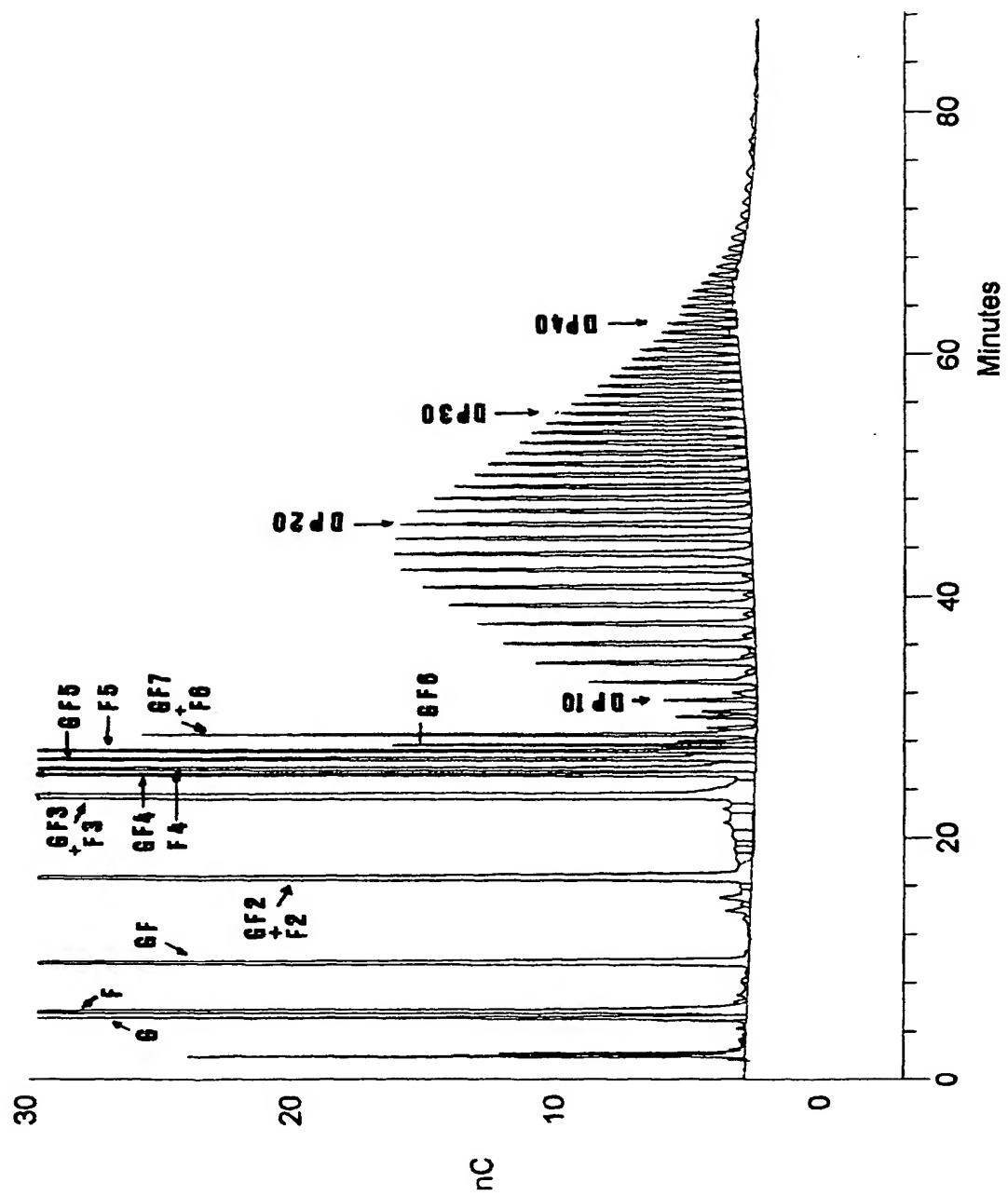


FIG. 1

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